

A Taxonomic Study of *Oconnorella* (Enchytraeidae, Oligochaeta) from Changbaishan Mountain, China

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We describe three enchytraeid species, including two new species, from Mt. Changbaishan, Jilin Province, northeastern China. *Oconnorella cheni* sp. nov. is characterized by a simple spermatheca; absence of the oesophageal appendages and seminal vesicle; and nephridia from 6/7, with a distinct funnel and the efferent duct arising from the anterior part of the postseptale. *Oconnorella globula* sp. nov. is distinguished by a spermatheca with two diverticula; lack of oesophageal appendages and seminal vesicle; and nephridia from 6/7, with distinct funnel and the efferent duct arising from the mid-ventral or posteroventral part of the postseptale. We redescribe *Oconnorella changbaishanensis* (Xie *et al.*, 2000) from type and live specimens, and amend some characters that cannot be investigated clearly from mounted specimens. We revise the generic diagnosis of *Oconnorella*.

Key words: Oligochaeta, Enchytraeidae, *Oconnorella*, Mt. Changbaishan, China

INTRODUCTION

O'Connor (1963) noted that several species of the terrestrial enchytraeid oligochaete genus *Marionina* (*M. tubifera*, *M. libra*, and *M. cambrensis*) should ultimately be transferred to other genera, but considered it premature to establish new genera until more species were discovered. Rota (1995) established the genus *Oconnorella* to accommodate a new species, *O. chalupskyi*, and a homogeneous group of species that had previously been included in *Marionina* (*M. tubifera* Nielsen and Christensen, 1959; *M. cambrensis* O'Connor, 1963; and *M. asymmetrica* Nurminen, 1970). Dózsa-Farkas (2002) re-examined specimens of *O. asymmetrica* and *O. tubifera* from the type localities, determined that *O. asymmetrica* was a junior synonym of *O. tubifera*, and proposed that *Marionina macrobulbi* Christensen and Dózsa-Farkas, 1999 and *M. changbaishanensis* Xie *et al.*, 2000 be transferred to *Oconnorella*. She considered *Oconnorella* to include four valid species: *O. tubifera* (Nielsen and Christensen, 1959), the type species of the genus; *O. cambrensis* (O'Connor, 1963); *O. macrobulbi* (Christensen and Dózsa-Farkas, 1999); and *O. changbaishanensis* (Xie *et al.*, 2000).

In September 2005, we conducted an investigation of the soil enchytraeid fauna on Mt. Changbaishan, Jilin Province, northeastern China. Among the specimens collected, we found three species of *Oconnorella*, which we describe herein. We recognized two of these as new to science and the third as a previously described species (Xie *et al.*, 2000).

MATERIALS AND METHODS

Specimens were extracted from soil by the wet-funnel method (O'Connor, 1962; Healy and Rota, 1992). All worms were examined and measured microscopically while alive, and most mature specimens could be identified to species without further treatment. Worms were preserved in 10% formalin following examination. For taxonomical observation, whole worms were stained in paracarmine, dehydrated in an alcohol series, and mounted in Canada balsam. Whole-mounted and formalin-preserved type specimens of the new species were deposited in the Museum of Aquatic Organisms (MAO), Institute of Hydrobiology, Chinese Academy of Science. For comparison with live specimens, the type series of *O. changbaishanensis* (Xie *et al.*, 2000) was reexamined.

All measurements of external and internal characteristics were made on living worms placed in a drop of water on a slide and covered with a cover glass, and all illustrations were drawn from live worms. Unless otherwise specified in the descriptions, measurements refer to whole-mounted specimens.

Abbreviations used in the figures are: **ad**, ampullar diverticula; **b**, brain; **co**, collar of sperm funnel; **dv**, dorsal vessel; **ecd**, spermathecal ectal duct; **eg**, ectal glands; **end**, spermathecal ental duct; **hp**, head pore; **ne**, nephridium; **ned**, nephridial efferent duct; **nf**, nephridial funnel (nephrostome); **oe**, oesophagus; **pg**, pharyngeal glands; **ph**, pharyngeal pad; **sa**, spermathecal ampulla; **sp**, spermatheca; **se**, septum; **sr**, sperm rings; **st**, setae; **vd**, vas deferens.

RESULTS

Family Enchytraeidae

Genus *Oconnorella* Rota, 1995

Type-species: *Oconnorella tubifera* (Nielsen and Christensen, 1959).

Amended diagnosis. Setae straight or slightly bent, without nodulus; in bundles containing more than two setae, shorter near centre of bundle. Head pore at 0/1. Dorsal pores absent. Transition between oesophagus and intestine

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gradual. Spongy oesophageal appendages bulging in the coelomic cavity of VI or VII, or absent. Three pairs of primary septal glands, all free dorsally. Nephridia with distinct funnel, anteseptale consisting of funnel only, efferent duct arising antero- or midventrally in preclitellar segments, posteroventrally or subterminally in posterior segments. Blood colourless. Dorsal vessel originating in or just behind the clitellar region. Brain longer than wide, concave or straight anteriorly, straight or slightly incised posteriorly. Coelomocytes of one type, uniform, oval, granular. Seminal vesicle present or absent. Penial bulb compact. Spermathecal ampullae simple or diverticulate.

Remarks. Rota (1995) proposed the diagnosis of the genus to include 1) setae straight, shorter near centre of bundle; 2) transition between oesophagus and intestine gradual; 3) dorsal vessel originating in or just behind the clitellar region; 4) spongy oesophageal appendages bulging in the coelomic cavity of VI or VII; and 5) nephridia with distinct funnel, anteseptale containing funnel only, efferent duct arising from anterior part of postseptale. Dózsa-Farkas (2002) amended the diagnosis of the genus, adding that the oesophageal appendages and seminal vesicle may be

present or absent; this author considered the genus to include four valid species (see Introduction).

This genus is distinct from other genera of Enchytraeidae in having the following combination of characters: 1) setae straight, shorter near centre of bundle; 2) the nephridia with distinct funnel, anteseptale consisting of funnel only; 3) dorsal vessel originating in or just behind the clitellar region; and 4) coelomocytes of one type, uniform kind, oval, granular.

***Oconnorella cheni* sp. nov.**

(Fig. 1 A–G)

Type series. Holotype, JLO20050018, a fully mature, whole-mounted specimen from a broadleaf Korean pine forest, Mt. Changbaishan, Jilin Province, (128°05'52"E, 42°24'12"N, 768 m above sea level), brown mountain soil with rich humus under roots of the arboreal Korean pine (*Pinus koraiensis*), soil water content 0.08, 13 Sept. 2005. Paratypes, JLO20050019–0021, three fully mature, whole-mounted specimens from type locality, data as for holotype.

Other material examined. Five mature specimens also from type locality were examined *in vivo*, after which all were

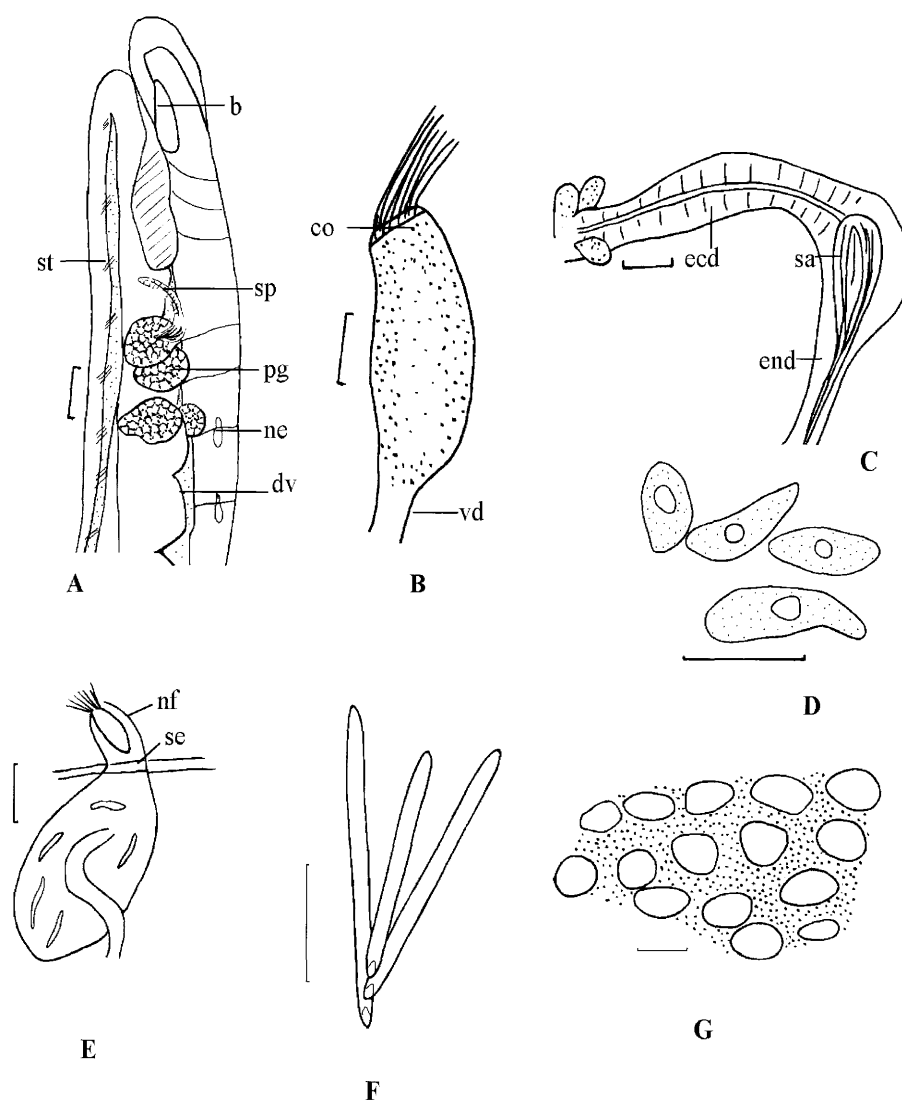


Fig. 1. *Oconnorella cheni* new species: **A**) lateral view of the worm; **B**) sperm funnel; **C**) spermatheca; **D**) coelomocytes; **E**) nephridium in 7/8; **F**) setae in VI; **G**) glands of the clitellum. Scales: A, 50 μ m; B, C, D, F, G, 25 μ m; E, 20 μ m.

preserved in 10% formalin.

Etymology. Named in honour of Yi Chen, a distinguished Chinese student of invertebrates, especially *Oligochaeta*.

Description. Small worms. Dimensions live: length 3–4.0 mm, width at V 150–175 μ m, width at clitellum 200–225 μ m. Fixed dimensions: length 2.5–3.6 mm, width at V 190–220 μ m, width at clitellum 240–275 μ m. Segments 27–31. Setae straight and pointed, hooked entally, those in the middle of bundle shorter than the outer ones (Fig. 1F), 40–45 μ m long by 2–3 μ m wide; setal formula 4–4, 3, 2: 4–3, 2. Head pore at 0/1, a longitudinal slit. Epidermal glands grey-whitish, inconspicuous, arranged in three or four rows per segment. Clitellum conspicuously elevated, in XII-1/2XIII. Hyalocytes and granulocytes irregularly arranged (Fig. 1G), ventrally interrupted between the two male pores. Two male pores separate, ventrolateral in middle of XII. Spermathecal pores paired in IV/V. Setae of XII lacking in mature specimens.

Brain in I-II, trapezoidal, truncate, or slightly convex anteriorly and concave posteriorly, 100–110 μ m long by 65–75 μ m wide *in vivo*, 90 μ m long by 50 μ m wide in fixed specimens. Three pairs of massive pharyngeal glands in IV–VI, the first pair connected dorsally, the other two pairs free dorsally; second and third pairs with ventral lobes (Fig. 1A). Gradual transition between oesophagus and intestine. No oesophageal and intestinal appendage. Chloragogen cells sparse, from VII onwards, granulated, containing oil globules. Dorsal vessel originates from XIII, anteriorly bifurcates behind pharynx. Blood colorless. Nephridia from 6/7 onwards, with five pairs in preclitellar region; anteseptale small, about 13 μ m long, containing nephrostome only; post-septale elongate, ca. 80 μ m long by 25 μ m wide *in vivo*.

Efferent duct originates anteriorly (Fig. 1E). Coelomocytes of one type, scarce, spindle-shaped or elliptical, ca. 25×13 μ m, finely granulated, with a visible nucleus (Fig. 1D).

Seminal vesicle absent. Sperm funnel pear-shaped, 75 μ m long by 37 μ m wide *in vivo*, 63 μ m by 25 μ m after fixation; collar narrower than funnel, about 28 μ m wide *in vivo* (Fig. 1B). Vasa deferentia loosely coiled in XII. Penial bulb compact, large, ca. 150×37 μ m, no accessory glands around male pores. Two or three eggs mature at a time.

Spermathecae paired in V–VI, ampulla pear-shaped, without diverticula, ca. 30 μ m long by 20 μ m wide, with scattered spermatozoa in ampulla. Ectal duct stout, the wall muscular, about 100 μ m long by 23 μ m wide *in vivo*, 75 μ m long by 13 μ m wide in fixed specimens. Three or four large gland cells at ectal pores. Two short ental ducts communicate separately with anterior oesophageal region of VI (Fig. 1C).

Remarks. This species can be regarded as belonging to the genus *Oconnorella*. Although its first pair pharyngeal glands connects dorsally, other characters such as the setal arrangement, anteseptale containing funnel only, and origin of the dorsal vessel agree well with the definition of the genus. *Oconnorella cheni* is somewhat similar to *O. tubifera* (Nielsen and Christensen, 1959) in the shape of the spermathecae and sperm funnel, and in the absence of a seminal vesicle. However, in addition to the pharyngeal gland mentioned above, it also differs from the latter in having smaller body size, fewer setae per bundle, a longitudinal slit as the head pore, absence of oesophageal appendages in VII, clitellar glands irregularly arranged and interrupted ventrally between the male pores, the origin of the first nephridium in preclitellar segments, and glands present at the spermathecal orifice (Table 1).

Table 1. Comparison of taxonomic features among six *Oconnorella* species.

Species	<i>O. tubifera</i>	<i>O. cambrensis</i>	<i>O. macrolulbi</i>	<i>O. changbaishanensis</i>	<i>O. cheni</i> sp. nov.	<i>O. globula</i> sp. nov.
References	Nielsen and Christensen, 1959; Rota, 1995	O'Connor, 1963	Christensen and Dózsa-Farkas, 1999	Xie <i>et al.</i> , 2000; this study	This study	This study
Body length	8–10 mm	5–8 mm	7–10 mm	8–11 mm	3–4.0 mm	2.9–4.2 mm
Segment number	36–39	31–41	26–35	34–42	27–31	24–34
Setal formula	2÷6–6÷3:3÷7,8–(8),7÷2	3,4–2÷4:4–2÷4	2,3,4–2,3,4:4,5–2,3	4–4, 3, 2 : 4–4, 3, 2	4–4,3,2:4–3,2	3,4–4,3:3,4? 4,3
Head pore	transverse	transverse	?	longitudinal	longitudinal	longitudinal
Epidermal glands	5–6 rows	3–5 rows	?	3–4 rows	3–4 rows	5–8 rows
Septal glands	3 pairs dorsally free, with ventral lobes	3 pairs dorsally free, with ventral lobes	3 pairs dorsally free, with ventral lobes, 2 secondary glands	3 pairs dorsally free, 2 nd and 3 rd with ventral lobes	first pair connected, others dorsally free, 2 nd and 3 rd with ventral lobes	3 pairs dorsally free, with ventral lobes
Oesophageal appendages	ventrolateral in VII	applied to the gut from IV, bulging in VI	absent	absent	absent	absent
Clitellum gland	XII-1/2XIII, transverse rows	1/2XI–XII or 1/2XII–XIII, transverse rows	XII-1/2XIII, transverse rows	XII-1/2XIII, transverse rows interrupted ventrally	XII-1/2XIII, irregularly arranged, interrupted ventrally	XII-1/2XIII, irregularly arranged, interrupted ventrally
Dorsal vessel	XII–XIII	XII–XIV	XII-1/2XIII	XII-1/2XIII	XII-1/2XIII	XII-1/2XIII
First nephridia at	5/6	6/7	?	6/7	6/7	6/7
Efferent duct origin	mid-anteroventral	mid-anteroventral	anteroventral	near septum to mid-ventral	anteroventral	mid-posteroventral
Sperm funnel	pear-shaped	cylindrical	cylindrical	cylindrical	pear-shaped	cylindrical
Spermathecal ampulla	oval	asymmetrical	2 diverticula	2 large diverticula	oval	2 diverticula
Glands at orifice	?	?	2–3 large glands	4–6	3–4 large	1 large
Seminal vesicle	absent	absent	small	large	absent	absent
Ental duct	merging or close	merging	merging	separate	separate	merging

***Oconnorella globula* sp. nov.**

(Fig. 2A–G)

Type series. Holotype, JLO20050022, a fully mature, whole-mounted specimen from a broadleaf Korean pine forest, Mt. Changbaishan, Jilin Province, (128°05'52"E, 42°24'12"N, 768 m above sea level), brown mountain soil with rich humus under roots of the arboreal Korean pine (*Pinus koraiensis*), soil water content 0.08, 13 Sept. 2005. Paratypes, JLO20050023–0025, three fully mature, whole-mounted specimens from the type locality, data as for holotype.

Other material examined. Around seven additional specimens were examined *in vivo*, after which all were preserved in 10% formalin.

Etymology. The species name is derived from the Latin *globulus* (globule), referring to the shape of the spermathecal diverticula.

Description. Live dimensions: length 5–6.5 mm, width

at V 200–230 μ m, width at clitellum 220–250 μ m. Fixed dimensions: length 2.9–4.2 mm, width at V 130–150 μ m, width at clitellum 170–250 μ m. Segments 24–34. Setae straight and pointed, entally hooked, those in the middle of bundle shorter than the outer ones (Fig. 2C), 30–40 μ m long. Setal formula 3,4–4,3: 3,4 4,3. Head pore at 0/1, a longitudinal slit. Epidermal glands inconspicuous, five to eight transverse rows per segment. Clitellum elevated conspicuously, in XII-1/2XIII, ventrally interrupted between the two male pores; gland cells small, arranged in 13–15 transverse rows, hyalocytes dominant (Fig. 2E). Two male pores separate, ventrolateral in middle of XII. Spermathecal pores paired in IV/V. Setae of XII lacking in mature specimens.

Brain in I–II, trapezoidal, concave anteriorly and truncate or rounded posteriorly, ca. 100 μ m long by 70 μ m wide *in vivo* and 75 μ m long by 50 μ m wide in fixed specimens (Fig. 2F). Three pairs of massive pharyngeal glands in IV–VI, all free dorsally; second and third pairs with ventral lobes (Fig. 2A). Gradual transition between oesophagus and intes-

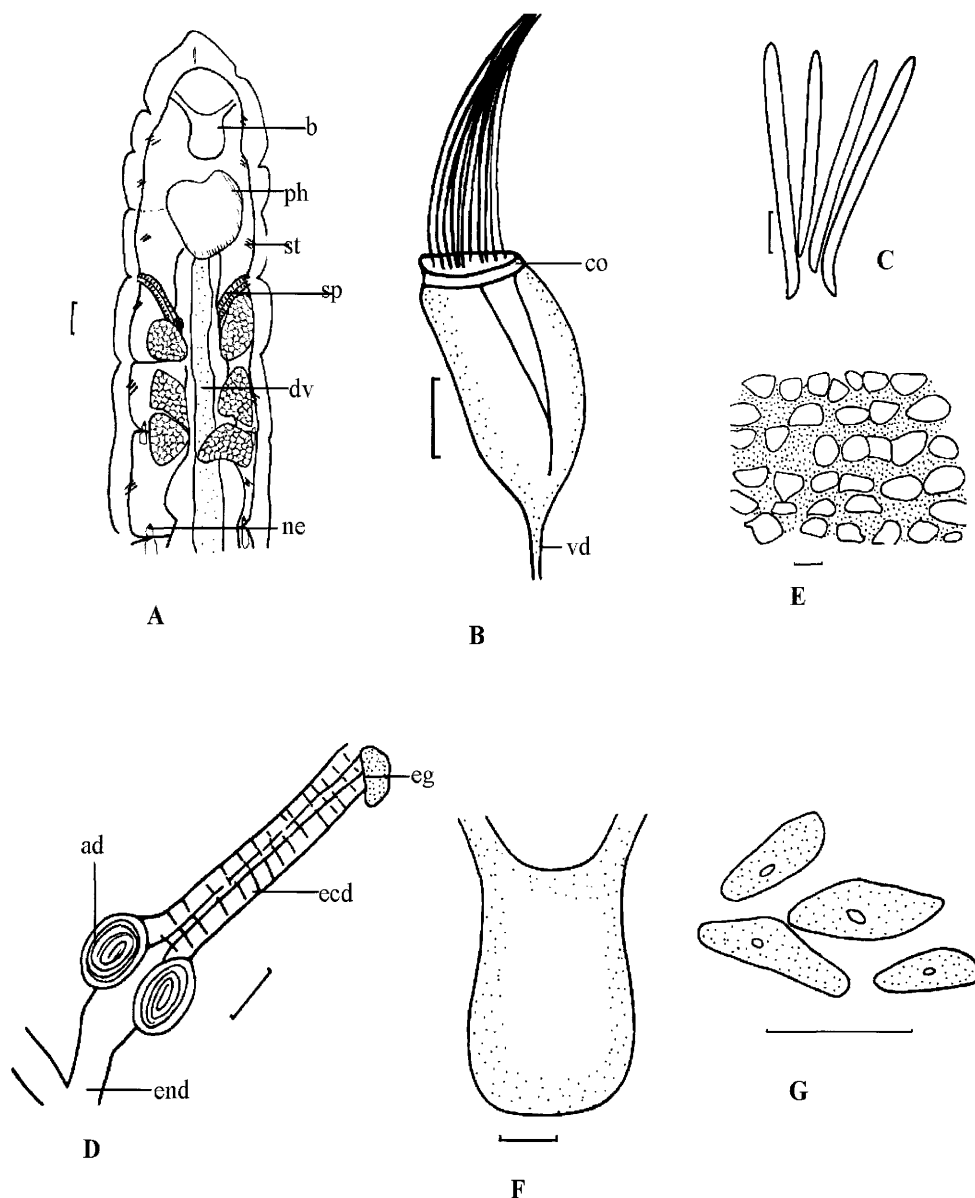


Fig. 2. *Oconnorella globula* new species: **A)** dorsal view of the worm; **B)** sperm funnel; **C)** dorsal setae in V; **D)** spermatheca; **E)** glands of the clitellum; **F)** brain; **G)** coelomocytes. Scales: A, 50 μ m; B, D, E, F, G, 25 μ m; C, 10 μ m.

tine. No oesophageal appendage. Chloragogen cells sparse, from VI onwards, granulated, containing oil globules. Dorsal vessel originates in XII and anteriorly bifurcates behind brain. Blood colourless. Nephridia from 6/7 onwards, with five pairs in preclitellar region. Anteseptale small, ca. 15 μm long by 8 μm wide *in vivo*, containing nephrostome only; postseptals elongate, ca. 72 μm long by 37 μm wide *in vivo*. Efferent duct originates midventrally or posteroventrally. Coelomocytes of one type, scarce, discoid, ca. 12–20 μm , finely granulated, faint brown, with a visible nucleus (Fig. 2G).

Seminal vesicle absent. Sperm funnel cylindrical, 57–88 μm long by 30–50 μm wide *in vivo*, 50–75 μm by 30–40 μm after fixation; collars not demarcated, as wide as the funnel, about 2.5–5 μm high *in vivo* (Fig. 2B). Heads of living spermatozoa 50–57 μm long, tails at least 100 μm long. Vasa deferentia regularly coiled in XII. Penial bulb compact, medium-sized, ca. 55 \times 50 μm . One or two eggs mature at a time.

Spermathecae paired in V–VI, ampulla globular, ca. 33 μm long, thin-walled, ectally bearing two small, oval, sessile diverticula, ca. 20 μm in size. Spermatozoa scattered in the diverticulum chamber. Ectal duct stout, the wall muscular, 53–60 μm long by 10–15 μm wide *in vivo*. One large gland

cell at the ectal pores. Two short ental ducts united and with a short common duct communicating with anterior oesophageal region of V/VI (Fig. 2D).

Remarks. At first sight, the new species seems very similar to *O. macrobulbi* (Christensen and Dózsa-Farkas, 1999) in having two globular diverticulae of the spermathecal ampulla and in the shape of the sperm funnel, number of setae per bundle, and absence of oesophageal appendages. The two species, however, differ in many characters. *Oconnorella macrobulbi* is larger (7–10 mm vs 5–6.5 mm), and the penial bulb is larger (150 μm vs 55 μm); there are two pairs of secondary septal glands and seminal vesicles (absent in *O. globula*), the nephridial duct is anteroventral (mid-posteroventral in *O. globula*), and the clitellar glands are regular (Table 1).

***Oconnorella changbaishanensis* (Xie *et al.*, 2000)**

(Fig. 3 A–F)

Marionina changbaishanensis Xie *et al.*, 2000, 143–146, Figs. 1–7.

Oconnorella changbaishanensis: Dózsa-Farkas, 2002, 86–90.

Material examined. Holotype, JLO19930015, a mature,

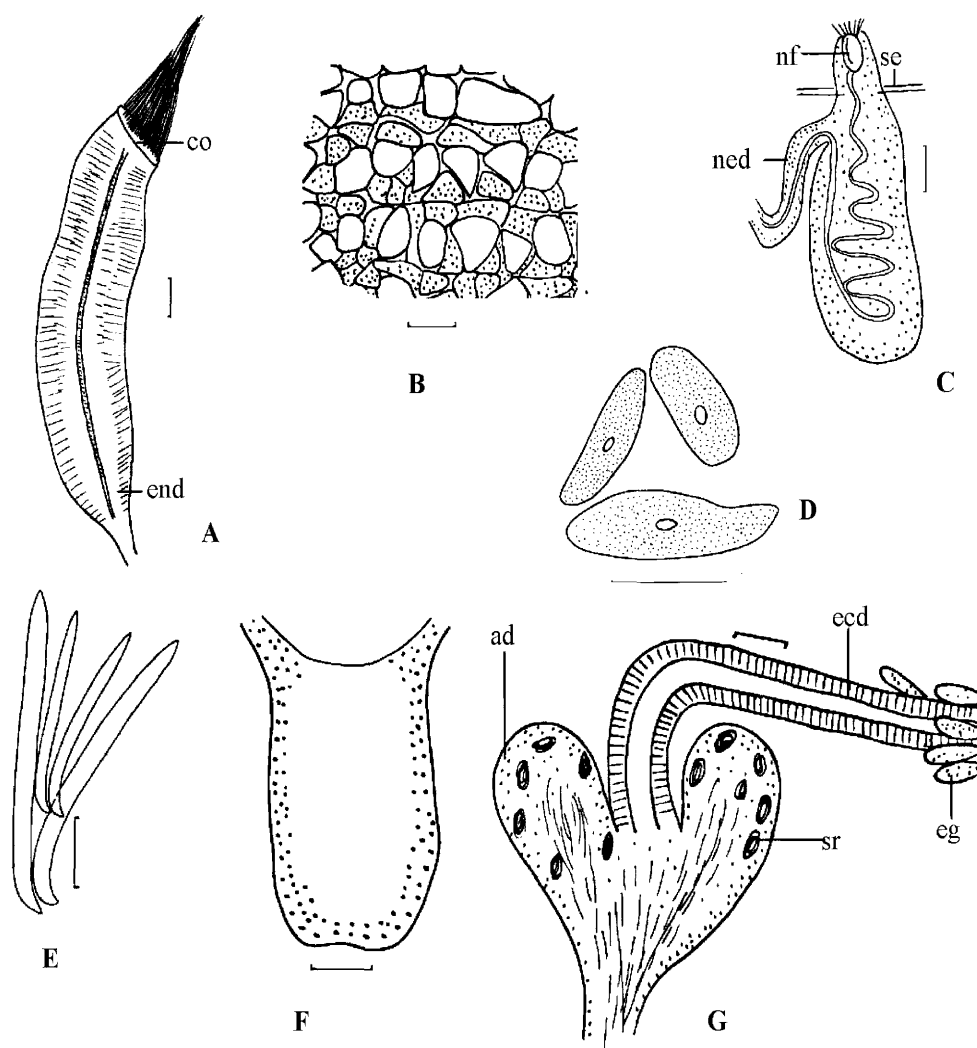


Fig. 3. *Oconnorella changbaishanensis* (Xie *et al.*, 2000): **A)** sperm funnel; **B)** gland cells of clitellum; **C)** nephridium in 7/8; **D)** coelomocytes; **E)** lateral setae in V; **F)** brain; **G)** spermatheca. Scales: A, D, F, 25 μm ; B, C, E, 50 μm .

whole-mounted specimen from Mt. Changbaishan (127°88'E, 41°95'N, 740 m above sea level), Jilin Province, Aug. 1993. Paratypes, JLO19930016–JLO19930018, three whole-mounted specimen from type locality. Other material examined: three mature specimens examined *in vivo*, from a broadleaf Korean pine forest, Mt. Changbaishan, Jilin Province, (128°05'52"E, 42°24'12"N, 768 m above sea level), brown mountain soil with rich humus under roots of the arboreal Korean pine (*Pinus koraiensis*), soil water content 0.08, 13 Sept. 2005.

Description. Live dimensions: length 8–11 mm, width at V 200–270 μ m, width at clitellum 280 μ m. Fixed dimensions: length 5–6 mm (holotype 5.5 mm), width at V 256 μ m, width at clitellum 320 μ m. Segments 20–42 (holotype 38). Head pore at 0/1, a longitudinal slit. Setae straight or slightly bent, simple-pointed, with distinct ental hook, those in middle of bundle shorter than outer ones, 51–54 μ m long by 4–5 μ m wide (larger setae up to 54 μ m long). Setal formula 3, 4–4, 3, 2:3, 4 4, 3, 2 (Fig. 3E). No dorsal pores. Epidermal glands inconspicuous, three or four transverse rows per segment. Clitellum elevated conspicuously, in XII-1/2 XIII, ventrally interrupted between the two male pores; gland cells ca. 10–20 μ m, irregularly arranged (Fig. 3B). Two male pores separated, ventrolateral in middle of XII. Spermathecal pores paired in IV/V. Chaetae of XII absent in mature specimens.

Brain in I–II, concave anteriorly and truncate or incised posteriorly, 85–90 μ m by 62–66 μ m (Fig. 3F). Three pairs of massive pharyngeal glands in IV–VI, all free dorsally, the first pair small and lacking ventral lobes, the others large and with distinct ventral lobes. No oesophageal or intestinal appendages. Gradual transition between oesophagus and intestine. Chloragogen cells sparse, from VII onwards. Dorsal vessel originating from XII or XIII. Blood colourless. Nephridia from 6/7 onwards, with five pairs in preclitellar region; anteseptale ca. 25 μ m long *in vivo* (in holotype 5–10 μ m long), containing nephrostome only; postseptale elongate, ca. 110 μ m long by 50 μ m wide *in vivo* (in holotype 58–65 μ m long). Efferent duct originating near septum in preclitellar region (Fig. 3C) and midventrally in postclitellar segments. Coelomocytes abundant, one type, discoid, ca. 25–40 μ m *in vivo* and 20–25 μ m in fixed specimens, finely granulated, with regular outline, faint brown, with a visible nucleus (Fig. 3D).

Seminal vesicle single, well developed, almost occupying the dorsal region of X–XI. Testes compact, finger-shaped, confined to XI. Sperm funnel cylindrical (Fig. 3A), large and long, occupying X–XII, 400 μ m long by 125 μ m wide *in vivo*, 350–380 μ m by 80–85 μ m after fixation; collars distinct, as wide as funnel, about 10 μ m high *in vivo*. Heads of spermatozoa ca. 30 μ m long. Vasa deferentia irregularly coiled in XII–XIII. Penial bulb sub-spherical, ca. 150 μ m long and 75 μ m high *in vivo*, ca. 100–104 μ m long and 60–75 μ m high in fixed specimens.

Spermathecae paired in V–VI, the ampulla cylindrical, with two large sub-spherical diverticula, bent towards the ectal duct, ca. 113 by 55 μ m (Fig. 3G). Spermatozoa scattered in ampulla and diverticular chambers, each forming

five to eight sperm rings near wall. Ectal duct stout, with thick, the wall muscular, 220 μ m long by 30 μ m wide *in vivo*, 130–140 μ m long by 20–22 μ m wide after fixation. Five or six conspicuous gland cells surround the base of spermathecal pore, their size ca. one-third the length of ectal duct. Two short ental ducts separately communicate with the anterior, dorsal oesophageal region of VI.

Remarks. Xie *et al.* (2000) originally described the efferent duct of the nephridium as arising posteroventrally or terminally. After examining live worms, we found that the efferent ducts originate near the septum in preclitellar segments and midventrally in the postclitellar region. In addition, the clitellar gland cells are sparse between the two male pores, which was not mentioned in the original description.

The main diagnostic features of this species are the head pore forming a longitudinal slit, the well-developed seminal vesicle, the origin of nephridial effect duct, the absence of oesophageal appendages, and two ampullar diverticula with distinct sperm rings (Table 1).

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